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Applicant HOTTINEN, Ari et al	

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PATENT COOPERATION TREATY

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IMPORTANT NOTIFICATION

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International filing date (day/month/year)
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1. The following indications appeared on record concerning:

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PATENT COOPERATION TREATY

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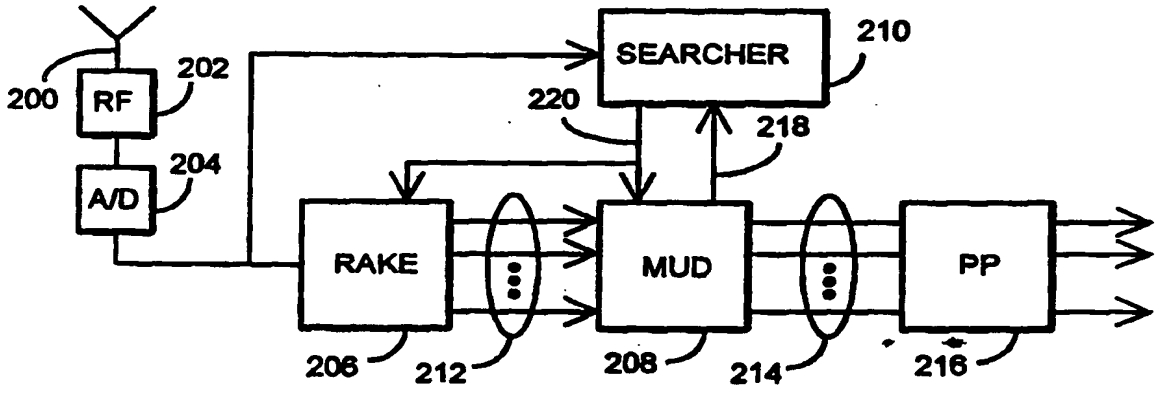

(57) Abstract

The invention relates to a reception method and a receiver in a system comprising in each cell a base station communicating with terminals located in its area. A received signal comprises a sum signal of signals originating from several transmitters. The receiver comprises means (208) for performing interference elimination and a simultaneous multi–user detection to the signal and means (210) for searching signal parameters. In order to reduce the required computational capacity, the receiver further comprises means (210) for removing the effect of the signals of the known users from the received sum signal, and means (210) for estimating the parameters of the unknown signals from a narrowband residual signal.

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RECEPTION METHOD AND RECEIVER

FIELD OF THE INVENTION

The invention relates to a reception method in a cellular radio system comprising in each cell at least one base station communicating with terminals located in its area and in which system Code Division Multiple Access is employed, and in which method a received signal comprises a sum signal of signals originating from several transmitters, said signals comprising symbols, and interference elimination and a simultaneous multi-user detection are performed to said signal and in which method an estimate is generated for the received signal.

The invention further relates to a reception method in a cellular radio system comprising in each cell at least one base station communicating with terminals located in its area and in which system Code Division Multiple Access is employed, and in which method a received signal comprises a sum signal of signals originating from several transmitters, and interference elimination and a simultaneous multi-user detection are performed to said signal.

DESCRIPTION OF THE PRIOR ART

The present invention is applicable in radio systems of several different types, for example CDMA systems. The CDMA is a multi-access method based on spread spectrum technique, and the method has recently been applied in cellular radio systems in addition to the previous FDMA and TDMA systems. The CDMA has several advantages over the previous methods, such as the simple frequency planning and spectral efficiency.

In the CDMA method, a narrowband user data signal is multiplied to a relatively broad band by a spreading code which is significantly more broadband than the data signal. Bandwidths used in the known test systems are, for example, 1.25 MHz, 10 MHz and 25 MHz. In connection with the multiplication, the data signal is spread over the whole band to be used. All users transmit simultaneously in the same frequency band. A unique spreading code is used on each connection between a base station and a mobile station, and the user signals can be distinguished from one another at the receivers on the basis of the spreading code of each user. The aim is to select the spreading codes in such a manner that they are mutually orthogonal, in other words they do not correlate with one another.

The correlators in the CDMA receivers implemented in a conventional way synchronize with a desired signal which is identified on the basis of a spreading code. The data signal is restored to the original band at the receiver by remultiplying it by the same spreading code as in the transmitting phase. The signals that are multiplied by some other spreading code do not, ideally, correlate and restore to the narrow band. Hence, they appear as noise to the desired signal. The aim is to detect the signal of a desired user from among several interfering signals. In practice, spreading codes are not orthogonal and other users' signals impede the detection of the desired signal by distorting the received signal nonlinearily. This mutual interference between the users is called multiple access interference. Similar multiple access interference occurs also in other multiple access methods, such as the TDMA and FDMA.

Numerous reception methods have been developed to eliminate the signal quality degradation caused by multiple access interference. Among these methods are the conventional single-user reception and the methods enabling a simultaneous multi-user detection. In the conventional single-user reception, the received transmission is correlated by a linear, matched filter ignoring all other signals comprised in the transmission than the signal of the desired user. This reception method is rapid to implement but extremely inefficient in multiple access interference elimination.

Methods have been disclosed in which multiple access interference is eliminated from a broadband signal and detection, in turn, is performed to a narrowband signal from which a spreading code is decoded. Such a method is disclosed in Thielecke, *Interference Reduction Applied to Channel Estimation in CDMA Systems*, Proceedings of Vehicular Technology Conference, 1994, Stockholm, which is incorporated herein by reference. However, in practice such methods are difficult to implement since signal processing is performed broadband, in other words on the chip level.

An optimal multi-user detector (MUD) comprises a number of linear matched filters and a Viterbi detector. A known linear multi-user detector is the least squares detector (LS detector) which is called a decorrelating detector. This detector requires data about the mutual cross-correlations of the codes used.

Furthermore, a drawback of the known methods is that they are developed for static systems, in other words for situations in which the number of

users is unchanged. In practice, however, radio systems comprise numerous factors that vary with time and which should be taken into account when designing receivers. New users are introduced to a cell in connection with handover or new calls. The number and quality of interfering signals supplied from adjacent cells also vary constantly.

BRIEF DESCRIPTION OF THE INVENTION

It is an object of the present invention to provide a reception method and a receiver by which the disadvantages of the previous solutions can be avoided. The solution of the invention enables a rapid and accurate synchronization on account of which the quality of connection setup and interference elimination is improved.

This is achieved by a method of the type described in the introduction, the method being characterized in that the estimate comprises one or more estimates of a received user signal, and that the effect of the symbols estimated on the symbol level is subtracted from the received sum signal, whereby a narrowband, symbol-level residual signal is obtained.

This is also achieved by a method of the type described in the introduction, the method being characterized in that an estimate comprises one or more estimates of a received user signal, and that the received sum signal is correlated by a particular spreading code, whereby a first symbol-level signal is obtained, and that the computed estimate is correlated by the same spreading code, whereby a second symbol-level signal is obtained, and that the second symbol-level signal is subtracted from the first symbol-level signal, whereby a narrowband, symbol-level residual signal is obtained.

The invention further relates to a receiver in a cellular radio system comprising in each cell at least one base station communicating with terminals located in its area, in which method a received signal comprises a sum signal of signals originating from several transmitters, said receiver comprising means for performing interference elimination and a simultaneous multi-user detection to the signal and means for searching signal parameters. The receiver of the invention is characterized in that the receiver further comprises means for removing the effect of the signals of the known users, and means for estimating the parameters of the unknown signals from a narrowband residual signal.

Several advantages can be achieved by the method of the invention. The method of the invention can rapidly notice dynamic changes, such as the signals of new users or unknown intruders, in the propagation environment of a radio path. In most cases, the solution of the invention also requires less processing capacity than the previous solutions. The solution of the invention requires no major changes in the existing equipment, but it can also be put to use at low cost in the current systems. The preferred embodiments of the invention are disclosed in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described in closer detail in the following with reference to the examples in accordance with the accompanying drawings, in which

Figure 1 shows a system to which the invention can be applied, and

Figure 2 is a block diagram illustrating the structure of the receiver of the invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention can be applied to radio systems of several different types, for example CDMA systems. In the following, the invention will be described in connection with the CDMA system without restricting to it.

Figure 1 illustrates the structure of a typical cellular radio system. The figure shows two cells 100, 102, each comprising a base station 104, 106. The cell 100 comprises three active terminals 108 to 112 communicating with the base station 104. Correspondingly, the cell 102 comprises two active terminals 116, 118 communicating with the base station 106.

The signals of the terminals are received at the base stations and a simultaneous multi-user detection is performed to the received signals. Let us examine the situation of the base station 104. The base station thus communicates with the active terminals 108 to 112 located in its area whose signals 120 to 124 it receives. The sum signal received by the base station antenna also comprises a signal 126 of the terminal located in an adjacent cell, which signal is an interfering one for the receiver. The base station 104 performs the simultaneous multi-user detection by a known MUD algorithm. It thus detects the desired signals 120 to 124 here and removes the effect of the interfering signal 126 from the desired signals. The effect of all other signals, not only the signal supplied from the adjacent cell can, of course, be removed from each

desired signal. This depends on implementation restrictions and the reliability of the estimate.

Let us next take a closer look at the receiver, in this example base station, of the invention by means of the block diagram in Figure 2. The receiver comprises an antenna 200 which receives a sum signal of signals originating from several transmitters. The antenna can be a single antenna or an antenna array comprising two or more antennas. From the antenna, the signal is conveyed to radio frequency parts 202 in which the signal is typically amplified and converted into an intermediate or baseband frequency. From the radio frequency parts the signal is conveyed to sampling means 204, in other words to an analogue/digital converter in which the signal is converted into a digital form by taking samples of it at a desired sampling frequency.

From the sampling means 202 the signal is conveyed to a correlator bank 206 comprising a number of correlators or matched filters, each synchronizing with one signal component of a sum signal, which they identify on the basis of the signal parameters. The correlators decode the spread coding of the signals, in other words convert it into narrowband. Narrowband signals 212 are conveyed to a detection unit 208 in which a simultaneous multi-user detection is performed. The soft decisions 214 of the desired signal symbols obtained from the detection unit are conveyed to a post-processing unit 216 and forwarded to the other parts of the receiver. In the post-processing unit 216 the signal is deinterleaved and channel-decoded, for example. How the signal is processed after the detection unit is not relevant.

The signal parameters required by the correlator bank comprise the spreading code, the data rate, the relative delay and optionally the amplitude used in the signal transmission. When any of the parameters is changed, the correlator must be updated. The spreading code may change when a user leaves or enters a cell, which may occur in connection with handover or switch-on.

Since data on these parameters is important, the receiver must, of course, monitor and estimate these changing parameters. This is performed in a so-called searcher unit 210. The sum signal received from the sampling means 202 is conveyed, in addition to the correlator bank, to the searcher unit 210 which searches for new signal components and their parameters.

The signal parameters estimated and computed by the searcher unit 210 comprise the number of active users, the physical channels, the

channel impulse response, the frame parameters and their functions. A correlation matrix between the codes is also computed in the searcher unit. The correlation matrix must be updated when dynamic changes occur on the channel, when the delays and bit rates change. The detection unit uses these data to compute the correlations between the signals in the simultaneous multi-user detection and interference elimination.

In the solution of the invention the operation of the searcher block is significantly alleviated in such a manner that, in addition to the received sum signal, a signal in which the effect of the signals of the known users is removed from the received sum signal is introduced as an input to the searcher unit. The parameters of the unknown signals can be significantly more easily estimated from this residual signal than from the original sum signal. The rapid operation of the receiver is important here, especially in connection with packet-form data.

When a new signal is found and its parameters are identified, two alternatives exist. If the signal is an interfering one, for example a signal of a terminal belonging to a neighboring cell, the effect of the signal found by means of the estimated parameters is removed from the received signal. If, however, the signal is a desired one, for example a terminal transferring to the area of the cell of the base station and desiring to set up a macrodiversity connection to the base station, the signal found by the estimated parameters is detected by using a simultaneous multi-user detection.

The estimation of the unknown signals may involve different alternatives. A receiver may have some advance information on the signals to be searched. The signals may be supplied from a neighboring cell, for example, whereby the base station of the neighboring cell can transmit the parameters of potential interfering signals in advance. In such a case, the spreading code may be known while the delay is unknown, for example. On the other hand, in a synchronous system the delay may be known while the spreading code is unknown. It is also possible that no parameter of an interfering signal is known in advance. On the other hand, in packet traffic or in connection with a random access transmission the code is known while the delay is unknown, for example.

When some of the parameters of the signals to be searched are known, these data are utilized when other parameters are searched, which, of course, makes the search more rapid.

For example, if a number of potential intruders is known, it is possible to compute the cross-correlations between the desired users and the potential interfering signals in advance. Next, utilizing the estimated symbols, known delays and codes, the effect of the known signals is removed from the received sum signal. Next, in order to reduce the search window, the unknown signals are searched from the residual signal by utilizing the advance data.

Let us next take a closer look at the mathematical basis of the solution of the invention. The received signal r is described by the formula

$$r = S_1 A_1 b_1 + n$$

in which matrix S comprises at time t all codes of the active users, A comprises at time t all channel coefficients of the active users, b comprises at time t all bits of the active users and n is noise. When a new user is introduced to a system, a new column which must be identified appears in matrix S in the above formula.

A known method to solve the problem is to correlate the received signal by a known code s_2 which does not belong to matrix S:

$$s_2^H \underline{r} .$$

On the basis of the correlation it is decided whether the new signal has been transmitted by using the particular code and at what delay the signal has been received. The codes and delays are examined one by one until the transmitter is found out by means of the correlation result.

Another method, which is disclosed in Thielecke above, is to make a decision on performing interference elimination on the basis of a broadband residual signal:

$$s_2^H [\underline{r} - \hat{S}_1 \hat{A}_1 \hat{b}_1] ,$$

in which the broadband estimate is subtracted from the received signal.

A preferred embodiment of the invention is based on processing the narrowband signal, in other words the signal which is obtained from the outputs of rake branches. In accordance with the method, the estimate of the known signal is generated first

$$\underline{\hat{r}_1} = \hat{S}_1 \hat{A}_1 \hat{b}_1 .$$

Next, the residual signal is correlated by the code to be searched

$$\hat{z}_{12} = \hat{s}_2^H [\hat{S}_1 \hat{A}_1 \hat{b}_1] = \hat{S}_2^H \hat{r}_1 ,$$

whereby an interference estimate is obtained for the narrowband signal. Next, the estimated narrowband signal is subtracted from the output of the $\hat{z}_{12}$ rake branches:

$$z_{r\omega} = z_2 - \hat{z}_{12}$$

and a decision is made on the narrowband residual signal. For the user k, the decision is made from the signal

$$z_{res} + \hat{a}_k \hat{b}_k ,$$

in which $\hat{a}_k$ is the channel estimate of one user.

The decision can be based on the strength of the residual signal or the channel estimate or amplitude estimate, for example. The residual signal can be combined on the symbol level either coherently or incoherently. The coherent combining can be implemented by transmitting a known training sequence or by means of a decision feedback. If a new signal does not comprise s_2, the signal-to-noise ratio of the residual signal is poor, and, in the contrary case, the operation reduces interference and improves the signal-to-noise ratio significantly. A great advantage of the method of the invention is that there is no need to compute the cross-correlation at any stage, so the method is significantly simpler to implement, even if the code changes symbol by symbol. On the other hand, if the code remains steady, i.e. unchanged symbol by symbol, the above computation can still be implemented in such a manner that the cross-correlation matrix $S_2^H * S_1$ is computed first and only after it $\hat{A}_1 \hat{b}_1$. Since the code does not change, the amount of computation does not increase significantly.

The computation of the narrowband residual signal is still rather a demanding procedure, so the methods that enable less frequent computation are advantageous. A way to do this is to apply a conventional correlator

$$s_2^H r,$$

by means of which a number of test delays is searched, among which the correct delay/code most probably is. A more accurate delay/code estimate based on the residual signal $z_{r\omega}$ can be computed for all test delays obtained in this way. Complexity can thus be reduced by the coefficient $|L_1| / |L_2|$, where $|L_1|$ is the number of the searched test delays and $|L_2|$ the number of all possible delays. The computation can, of course, be performed to several test delays in parallel or sequentially one delay at a time.

In another preferred embodiment of the invention, at least one estimate of an interfering signal is removed from the received signal and the parameters of the unknown signals are estimated from the residual signal obtained. This alternative is advantageous when a random access signal is involved, for example. In such a case, the interfering signal only produces a

one-time effect. The effect of the signal can be removed from the received transmission, and the parameters of the unknown signals are estimated from the less interfering residual signal obtained in this way. The interfering signal estimate comprises the complex amplitude, channel coefficient, delay, etc.

Let us next take a closer look at the structure of the receiver, in this example the base station, of the invention by means of the block diagram in Figure 2. The receiver thus comprises the correlator bank 206 which comprises a number of correlators or matched filters whose output comprises the signals 212 that are multiplied by known spreading codes and converted into narrowband. The detection means 208 perform interference elimination and the simultaneous multi-user detection to the signals 212.

The receiver further comprises the means 210 for searching signal parameters. The received sum signal is introduced to the searcher means as one input. From the detection means 208, data 218 on the known signal parameters is conveyed to the searcher means. The signal 218 comprises data on the number of the detected signals, the preliminary delay estimates for each signal and the active code set, for example. The searcher means remove the effect of the signals of the known users from the received sum signal and estimate the parameters of the unknown signals from the residual signal, as described above. The parameters 220 computed by the searcher means are conveyed to the correlator bank 206 and to the detection unit 208 to be utilized. The searcher means 210 and the detection means 208 can be advantageously implemented in practice by software, using a signal processor or a multi-purpose processor or, alternatively, discrete components or ASIC circuits.

Even though the invention is described above with reference to the example in accordance with the accompanying drawings, it is obvious that the invention is not restricted to it but can be modified in many ways within the scope of the inventive idea disclosed in the attached claims.

CLAIMS

1. A reception method in a cellular radio system comprising in each cell at least one base station communicating with terminals located in its area and in which system Code Division Multiple Access is employed, and in which method a received signal comprises a sum signal of signals originating from several transmitters, said signals comprising symbols, and interference elimination and a simultaneous multi-user detection are performed to said signal and in which method an estimate is generated for the received signal, **characterized** in that

the estimate comprises one or more estimates of a received user signal,

and that the effect of the symbols estimated on the symbol level is subtracted from the received sum signal, whereby a narrowband, symbol-level residual signal is obtained.

2. A reception method in a cellular radio system comprising in each cell at least one base station communicating with terminals located in its area and in which system Code Division Multiple Access is employed, and in which method a received signal comprises a sum signal of signals originating from several transmitters, and interference elimination and a simultaneous multi-user detection are performed to said signal, **characterized** in that

an estimate comprises one or more estimates of a received user signal,

and that the received sum signal is correlated by a particular spreading code, whereby a first symbol-level signal is obtained,

and that the computed estimate is correlated by the same spreading code, whereby a second symbol-level signal is obtained,

and that the second symbol-level signal is subtracted from the first symbol level signal, whereby a narrowband, symbol-level residual signal is obtained.

3. A method as claimed in claim 1 or 2, **characterized** in that the parameters of the unknown signals are estimated from the narrowband residual signal.

4. A method as claimed in claim 1, **characterized** in that a decision whether new user signals have been found is made by means of parameters.

5. A method as claimed in claim 3, **characterized** in that by means of the estimated parameters the found signals are detected using the simultaneous multi-user detection.

6. A method as claimed in claim 1 or 2, **characterized** in that the received sum signal is first conveyed to a number of matched filters (206) in which the parameters of the known signals are estimated, and said signals are conveyed to a detector (208) in which the simultaneous multi-user detection is performed.

7. A method as claimed in claim 6, **characterized** in that the signal parameters comprise the signals' phase, amplitude and spreading code used.

8. A method as claimed in claim 6, **characterized** in that the signal parameters are estimated in parallel.

9. A method as claimed in claim 6, **characterized** in that the signal parameters are estimated sequentially.

10. A method as claimed in claim 6, **characterized** in that when some parameters of the unknown signals are known, these data are utilized when other parameters are searched.

11. A method as claimed in claim 1 or 2, **characterized** in that the residual signal comprises user symbols and that the symbols are combined incoherently.

12. A method as claimed in claim 1 or 2, **characterized** in that the residual signal comprises user symbols and that the symbols are combined coherently.

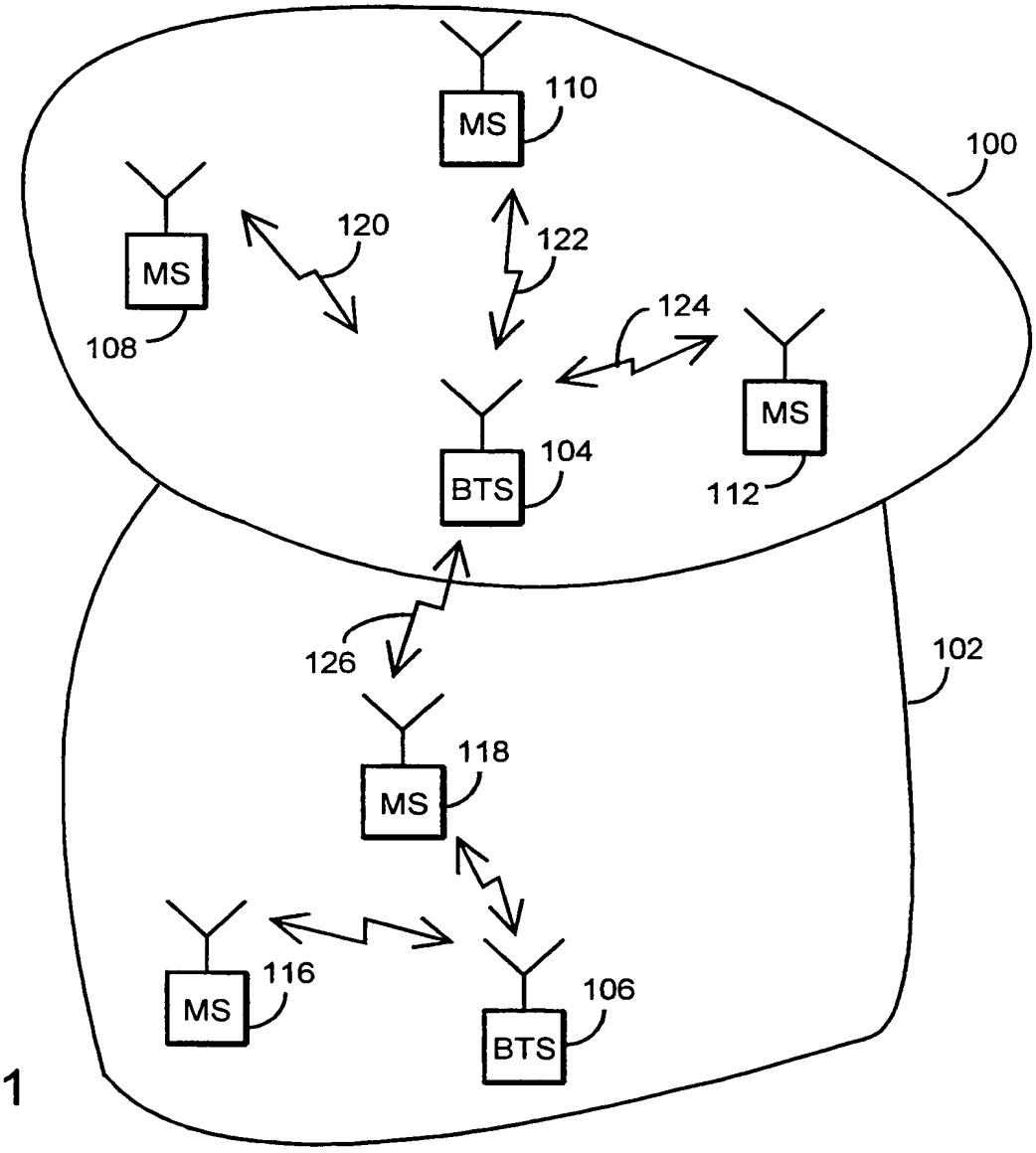
13. A method as claimed in claim 1 or 2, **characterized** in that the parameters are estimated in several stages in such a manner that preliminary estimates are searched first, whereupon a more accurate, final estimate is estimated from among the found, preliminary estimates.

14. A receiver in a cellular radio system comprising in each cell at least one base station communicating with terminals located in its area, in which method a received signal comprises a sum signal of signals originating from several transmitters, said receiver comprising means (208) for performing interference elimination and a simultaneous multi-user detection to the signal and means (210) for searching signal parameters, **characterized** in that the receiver further comprises means (210) for removing the effect of the signals of the known users from the received symbol-level sum signal, and

means (210) for estimating the parameters of the unknown signals from a narrowband residual signal.

15. A receiver as claimed in claim 14, **characterized** in that the receiver further comprises means (208) for removing, by means of the estimated parameters, the effect of the found signals from the received signal.

16. A receiver as claimed in claim 14, **characterized** in that the receiver further comprises means (208) for detecting, by means of the estimated parameters, the found signals, using the simultaneous multi-user detection.


MS
110
100
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120
122
108
124
MS
BTS
104
112
126
102
MS
118
MS
116
BTS
106

Fig. 1

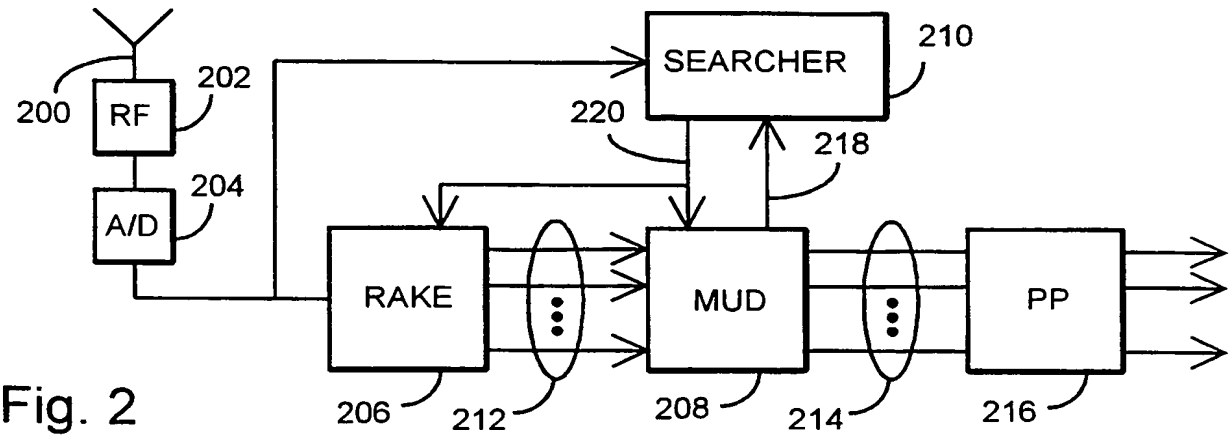
200
RF
202
A/D
204
SEARCHER
210
220
218
RAKE
MUD
PP
206
212
208
214
216

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 98/00548

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04B 1/10
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04B, H04J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, JAPIO

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0711044 A2 (NOKIA MOBILE PHONES LTD.), 30 October 1995 (30.10.95), column 3, line 39 - column 4, line 54, see the whole document	1,2,14
A	--	3-13,15-16
X	WO 9400917 A1 (MOTOROLA INC.), 6 January 1994 (06.01.94), page 24, line 5 - line 27, see the whole document	1,2,14
A	--	3-13,15-16
P,A	EP 0849886 A2 (FUJITSU LIMITED), 19 December 1997 (19.12.97), see the whole document	1-16
	--	

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 November 1998	01 -12- 1998
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Rune Bengtsson Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 98/00548

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9611534 A2 (NOKIA TELECOMMUNICATIONS OY), 18 April 1996 (18.04.96), see the whole document -- --------	1-16

INTERNATIONAL SEARCH REPORT

Information on patent family members

03/11/98

International application No.
PCT/FI 98/00548

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0711044 A2	30/10/95	FI 97180 B,C	15/07/96
		FI 945190 A	04/05/96
		JP 8237190 A	13/09/96
WO 9400917 A1	06/01/94	BR 9305563 A	26/12/95
		CA 2116127 A	06/01/94
		CN 1082287 A	16/02/94
		DE 4392999 T	31/07/97
		FI 940952 A	28/02/94
		JP 6510415 T	17/11/94
		KR 9612479 B	20/09/96
		MX 9303883 A	31/01/94
		SE 9400545 A	20/04/94
		US 5224122 A	29/06/93
		US 5325394 A	28/06/94
EP 0849886 A2	19/12/97	JP 10190496 A	21/07/98
WO 9611534 A2	18/04/96	AU 695984 B	27/08/98
		AU 3654995 A	02/05/96
		CN 1159870 A	17/09/97
		EP 0784888 A	23/07/97
		FI 944739 A	08/04/96
		NO 971543 A	05/06/97

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

REC'D 27 OCT 1999
WIPO PCT

Applicant's or agent's file reference T296069PC/nu	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/FI98/00548	International filing date *(day/month/year)* 23.06.1998	Priority date *(day/month/year)* 23.06.1997
International Patent Classification (IPC) or national classification and IPC6 H 04 B 1/10		
Applicant Nokia [Telecommunications] OY et al NETWORKS		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

   ☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of _____ sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
21.01.1999	12.10.1999
Name and mailing address of the IPEA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Telex 17978 PATOREG-S Facsimile No. 08-667 72 88	Authorized officer Rune Bengtsson/MN Telephone No. 08-782 25 00

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/FI98/00548

I. Basis of the report

1. This report has been drawn on the basis of *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.)*:

☒ the international application as originally filed.

☐ the description, pages _____ , as originally filed,
pages _____ , filed with the demand,
pages _____ , filed with the letter of _____ ,
pages _____ , filed with the letter of _____ .

☐ the claims, Nos. _____ , as originally filed,
Nos. _____ , as amended under Article 19,
Nos. _____ , filed with the demand,
Nos. _____ , filed with the letter of _____ ,
Nos. _____ , filed with the letter of _____ .

☐ the drawings, ~~sheets~~/fig _____ , as originally filed,
~~sheets~~/fig _____ , filed with the demand
~~sheets~~/fig _____ , filed with the letter of _____ ,
~~sheets~~/fig _____ , filed with the letter of _____ .

2. The amendments have resulted in the cancellation of:

☐ the description, pages _____
☐ the claims, Nos. _____
☐ the drawings, ~~sheets~~/fig _____

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the supplemental Box (Rule 70.2(c)).

4. Additional observations, if necessary:

V. Resoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-16	YES
	Claims		NO
Inventive step (IS)	Claims		YES
	Claims	1-16	NO
Industrial applicability (IA)	Claims	1-16	YES
	Claims		NO

2. Citations and explanations

The claimed invention is a reception method and receiver in a cellular radio system. Interference elimination and simultaneous multi-user detection are performed and an estimate is generated for the received signal. A residual signal is obtained by subtracting the effect of the symbols estimated on the symbol level from the received sum signal. The parameters of the unknown signals are then estimated from the narrow band residual signal.

D1) EP 0711044 A2 (see column 3, row 39 - column 4, row 54)
D2) WO 9400917 A1

Document **D1** presents a channel estimation method in a CDMA receiver. The channel estimation is based on a received signal that has undergone elimination of multiple access interference.

Document **D2** shows a method and apparatus for cancelling spread-spectrum noise. The multipath components of the user's own signal are subtracted from each other to minimise the effect of intersymbol interference. Document D2 does not mention anything about the elimination of multi-user interference.

Claims 1, 2, 14
In document D1, the symbol estimates are computed for the received transmission. The receiver comprises a first estimation whose transmission is a received and digitalized signal and a second estimation in which channel parameters of the interference-free signal are estimated. It also uses signal subtraction in serial mode and correlation with a code of a given user.

.../...

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: V

In relation to the claimed invention in claims 1, 2 and 14, D1 does not use signal subtraction on symbol level but requires signal subtraction on chip level. The wording "symbol level" as in claim 1 is understood to refer to decorrelated sequences (see description p.3, lines 17-24). To perform symbol estimation on decorrelated sequences as such, is considered well known.

Further, to subtract estimated symbols in multi-user detection on symbol level in place of chip level as in D1 is considered obvious for a person skilled in the art.

Consequently, the claimed invention is not considered to involve an inventive step.

Claims 3-13, 15-16
To use or estimate parameters in different ways is obvious for a person skilled in the art.

Therefore, the invention claimed in claims 1-16 is novel, comprise industrial applicability, but is **not considered to involve an inventive step**

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference T296069PC/nu	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/FI98/00548	International filing date *(day/month/year)* 23.06.1998	Priority date *(day/month/year)* 23.06.1997
International Patent Classification (IPC) or national classification and IPC6 H 04 B 1/10		
Applicant Nokia Telecommunications OY et al		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

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- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
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- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
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Date of submission of the demand	Date of completion of this report
21.01.1999	12.10.1999
Name and mailing address of the IPEA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Telex 17978 PATOREG-S Facsimile No. 08-667 72 88	Authorized officer Rune Bengtsson/MN Telephone No. 08-782 25 00

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/FI98/00548

I. Basis of the report

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☒ the international application as originally filed.

☐ the description, pages _____ , as originally filed,
pages _____ , filed with the demand,
pages _____ , filed with the letter of _____ ,
pages _____ , filed with the letter of _____ .

☐ the claims, Nos. _____ , as originally filed,
Nos. _____ , as amended under Article 19,
Nos. _____ , filed with the demand,
Nos. _____ , filed with the letter of _____ ,
Nos. _____ , filed with the letter of _____ .

☐ the drawings, ~~sheets~~/fig _____ , as originally filed,
~~sheets~~/fig _____ , filed with the demand
~~sheets~~/fig _____ , filed with the letter of _____ ,
~~sheets~~/fig _____ , filed with the letter of _____ .

2. The amendments have resulted in the cancellation of:

☐ the description, pages _____
☐ the claims, Nos. _____
☐ the drawings, ~~sheets~~/fig _____

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the supplemental Box (Rule 70.2(c)).

4. Additional observations, if necessary:

V. Resoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

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Novelty (N)	Claims	1-16	YES
	Claims		NO
Inventive step (IS)	Claims		YES
	Claims	1-16	NO
Industrial applicability (IA)	Claims	1-16	YES
	Claims		NO

2. Citations and explanations

The claimed invention is a reception method and receiver in a cellular radio system. Interference elimination and simultaneous multi-user detection are performed and an estimate is generated for the received signal. A residual signal is obtained by subtracting the effect of the symbols estimated on the symbol level from the received sum signal. The parameters of the unknown signals are then estimated from the narrow band residual signal.

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Document **D1** presents a channel estimation method in a CDMA receiver. The channel estimation is based on a received signal that has undergone elimination of multiple access interference.

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.../...

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: V

In relation to the claimed invention in claims 1, 2 and 14, D1 does not use signal subtraction on symbol level but requires signal subtraction on chip level. The wording "symbol level" as in claim 1 is understood to refer to decorrelated sequences (see description p.3, lines 17-24). To perform symbol estimation on decorrelated sequences as such, is considered well known.

Further, to subtract estimated symbols in multi-user detection on symbol level in place of chip level as in D1 is considered obvious for a person skilled in the art.

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Claims 3-13, 15-16
To use or estimate parameters in different ways is obvious for a person skilled in the art.

Therefore, the invention claimed in claims 1-16 is novel, comprise industrial applicability, but is **not considered to involve an inventive step**

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 98/00548

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04B 1/10
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04B, H04J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, JAPIO

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0711044 A2 (NOKIA MOBILE PHONES LTD.), 30 October 1995 (30.10.95), column 3, line 39 - column 4, line 54, see the whole document	1,2,14
A	--	3-13,15-16
X	WO 9400917 A1 (MOTOROLA INC.), 6 January 1994 (06.01.94), page 24, line 5 - line 27, see the whole document	1,2,14
A	--	3-13,15-16
P,A	EP 0849886 A2 (FUJITSU LIMITED), 19 December 1997 (19.12.97), see the whole document	1-16
	--	

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 November 1998	01 -12- 1998
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Rune Bengtsson Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 98/00548

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9611534 A2 (NOKIA TELECOMMUNICATIONS OY), 18 April 1996 (18.04.96), see the whole document	1-16

--

INTERNATIONAL SEARCH REPORT

Information on patent family members

03/11/98

International application No.
PCT/FI 98/00548

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0711044 A2	30/10/95	FI 97180 B,C	15/07/96
		FI 945190 A	04/05/96
		JP 8237190 A	13/09/96
WO 9400917 A1	06/01/94	BR 9305563 A	26/12/95
		CA 2116127 A	06/01/94
		CN 1082287 A	16/02/94
		DE 4392999 T	31/07/97
		FI 940952 A	28/02/94
		JP 6510415 T	17/11/94
		KR 9612479 B	20/09/96
		MX 9303883 A	31/01/94
		SE 9400545 A	20/04/94
		US 5224122 A	29/06/93
		US 5325394 A	28/06/94
EP 0849886 A2	19/12/97	JP 10190496 A	21/07/98
WO 9611534 A2	18/04/96	AU 695984 B	27/08/98
		AU 3654995 A	02/05/96
		CN 1159870 A	17/09/97
		EP 0784888 A	23/07/97
		FI 944739 A	08/04/96
		NO 971543 A	05/06/97

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PCT/FI98/00548
International Application No.

International Filing Date 23 JUN 1998 (23.06.98)

The Finnish Patent Office
PCT International Application
Name of receiving Office and "PCT International Application"

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

Applicant's or agent's file reference
(if desired) (12 characters maximum) T296069PC/su

Box No. I TITLE OF INVENTION

Reception method and receiver

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e.. country) of residence if no State of residence is indicated below.)*

NOKIA TELECOMMUNICATIONS OY
Keilalahdentie 4
FIN-02150 Espoo
Finland

☐ This person is also inventor

Telephone No.

Facsimile No.

Teleprinter No.

State *(i.e. country)* of nationality: FI

State *(i.e. country)* of residence: FI

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e.. country) of residence if no State of residence is indicated below.)*

HOTTINEN Ari
Ristiniementie 4 D 30
FIN-02320 Espoo
Finland

This person is:

☐ applicant only

☒ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: FI

State *(i.e. country)* of residence: FI

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

PATENTTITOIMISTO TEKNOPOLIS KOLSTER OY
C/O KOLSTER OY AB
Iso Roobertinkatu 23
P.O. Box 148
FIN-00121 Helsinki
Finland

Telephone No.
358-9-618821

Facsimile No.
358-9-602244

Teleprinter No.

☐ Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

If none of the following sub-boxes is used, this sheet is not to be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e., country) of residence if no State of residence is indicated below.)*

LILLEBERG Jorma
Mustaherukkatie 1 A
FIN- 90800 Oulu
Finland

This person is:

- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: FI

State *(i.e. country)* of residence: FI

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e., country) of residence if no State of residence is indicated below.)*

TOSKALA Antti
Väinämöisenkatu 25 A 13
FIN- 00100 Helsinki
Finland

This person is:

- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: FI

State *(i.e. country)* of residence: FI

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e., country) of residence if no State of residence is indicated below.)*

HOLMA Harri
Itätuulenkuja 1 B 32
FIN- 02100 Espoo
Finland

This person is:

- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

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☐ Further applicants and/or (further) inventors are indicated on another continuation sheet.

PCT/FI98/00548

Box No. V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked)*:

Regional Patent

- ☒ **AP** **ARIPO Patent:** GH Ghana, GM Gambia, KE Kenya, LS Lesotho, MW Malawi, SD Sudan, SZ Swaziland, UG Uganda, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT
- ☒ **EA** **Eurasian Patent:** AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT
- ☒ **EP** **European Patent:** AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, CY Cyprus, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- ☒ **OA** **OAPI Patent:** BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)*

.....

National patent *(if other kind of protection or treatment desired, specify on dotted line)*:

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- ☒ **AT** Austria and utility model .....
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- ☒ **KG** Kyrgyzstan .....
- ☒ **KP** Democratic People's Republic of Korea .....

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- ☒ **KR** Republic of Korea .....
- ☒ **KZ** Kazakstan .....
- ☒ **LC** Saint Lucia
- ☒ **LK** Sri Lanka
- ☒ **LR** Liberia
- ☒ **LS** Lesotho .....
- ☒ **LT** Lithuania
- ☒ **LU** Luxembourg .....
- ☒ **LV** Latvia
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- ☒ **MG** Madagascar .....
- ☒ **MK** The former Yugoslav Republic of Macedonia

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- ☒ **UG** Uganda .....
- ☒ **US** United States of America .....

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- ☒ **UZ** Uzbekistan .....
- ☒ **VN** Viet Nam .....
- ☒ **YU** Yugoslavia .....
- ☒ **ZW** Zimbabwe .....

Check-boxes reserved for designating States (for the purposes of a national patent) which have become party to the PCT after issuance of this sheet

- ☐ .....
- ☐ .....
- ☐ .....

In addition to the designations made above, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except the designation(s) of _____.

The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)*

See Notes to the request form

PCT/FI98/00548

Box No. VI 'PRIORITY CLAIM Further priority claims are indicated in the Supplemental Box ☐

The priority of the following earlier application(s) is hereby claimed:

Country *(in which, or for which, the application was filed)*	Filing Date *(day/month/year)*	Application No.	Office of filing *(only for regional or international application)*
item (1) FI	23 June 1997 (23.06.1997)	972704	
item (2)			
item (3)			

Mark the following check-box if the certified copy of the earlier application is to be issued by the Office which for the purposes of the present international application is the receiving Office (a fee may be required):

☒ The receiving Office is hereby requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s) : (1)

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(If two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):* **ISA /SE**

Earlier search *Fill in where a search (international, international-type or other) by the International Searching Authority has already been carried out or requested and the Authority is now requested to base the international search to the extent possible, on the results of that earlier search. Identify such search or request either by reference to the relevant application (or the translation thereof) or by reference to the search request*

Country (or regional Office): Date *(day/month/year):* Number:

Box No. VIII CHECK LIST

This international application contains the following number of sheets:

1. request	:	4 sheets
2. description	:	12 sheets
3. claims	:	3 sheets
4. abstract	:	1 sheets
5. drawings	:	1 sheets
Total	:	**21** sheets

This international application is accompanied by the item(s) marked below

1. ☐ separate signed power of attorney
2. ☐ copy of general power of attorney
3. ☐ statement explaining lack of signature
4. ☐ priority document(s) *identified in Box No. VI as item(s):*
5. ☒ fee calculation sheet
6. ☐ separate indications concerning deposited microorganisms
7. ☐ nucleotide and/or amino acid sequence listing diskette)
8. ☒ other *(specify):* official action

Figure No. 2 of the drawings (if any) should accompany the abstract when it is published.

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request)

PATENTTITOIMISTO TEKNOPOLIS KOLSTER OY

Taplo Äkräs

For receiving Office use only

1. Date of actual receipt of the purported international application:	23 JUN 1998 (23-06-1998)	2. Drawings: ☐ received ☐ not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:		
4. Date of timely receipt of the required corrections under PCT Article 11(2):		
5. International Searching Authority specified by the applicant: ISA/ SE	6. ☐ Transmittal of search copy delayed until search fee is paid	

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Date of receipt of the record copy by the International Bureau:

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PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office only

PCT/FI98/00548
International Application No.

International Filing Date 23 JUN 1998 (23.06.98)

The Finnish Patent Office
PCT International Application
Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference
(if desired) (12 characters maximum) T296069PC/su

Box No. I TITLE OF INVENTION

Reception method and receiver

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e.. country) of residence if no State of residence is indicated below.)*

NOKIA TELECOMMUNICATIONS OY
Keilalahdentie 4
FIN-02150 Espoo
Finland

☐ This person is also inventor

Telephone No.

Facsimile No.

Teleprinter No.

State *(i.e. country)* of nationality: FI

State *(i.e. country)* of residence: FI

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e.. country) of residence if no State of residence is indicated below.)*

HOTTINEN Ari
Ristiniementie 4 D 30
FIN- 02320 Espoo
Finland

This person is:

☐ applicant only

☒ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: FI

State *(i.e. country)* of residence: FI

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

PATENTTITOIMISTO TEKNOPOLIS KOLSTER OY
C/O KOLSTER OY AB
Iso Roobertinkatu 23
P.O. Box 148
FIN-00121 Helsinki
Finland

Telephone No.
358-9-618821

Facsimile No.
358-9-602244

Teleprinter No.

☐ Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

PCT / FI98 / 00548

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

If none of the following sub-boxes is used, this sheet is not to be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e., country) of residence if no State of residence is indicated below.)*

LILLEBERG Jorma
Mustaherukkatie 1 A
FIN- 90800 Oulu
Finland

This person is:

- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: FI

State *(i.e. country)* of residence: FI

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e., country) of residence if no State of residence is indicated below.)*

TOSKALA Antti
Väinämöisenkatu 25 A 13
FIN- 00100 Helsinki
Finland

This person is:

- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: FI

State *(i.e. country)* of residence: FI

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

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HOLMA Harri
Itätuulenkuja 1 B 32
FIN- 02100 Espoo
Finland

This person is:

- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: FI

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☐ Further applicants and/or (further) inventors are indicated on another continuation sheet.

Box No. V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked)*:

Regional Patent

- ☒ **AP** **ARIPO Patent:** **GH** Ghana, **GM** Gambia, **KE** Kenya, **LS** Lesotho, **MW** Malawi, **SD** Sudan, **SZ** Swaziland, **UG** Uganda, **ZW** Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT
- ☒ **EA** **Eurasian Patent:** **AM** Armenia, **AZ** Azerbaijan, **BY** Belarus, **KG** Kyrgyzstan, **KZ** Kazakstan, **MD** Republic of Moldova, **RU** Russian Federation, **TJ** Tajikistan, **TM** Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT
- ☒ **EP** **European Patent:** **AT** Austria, **BE** Belgium, **CH and LI** Switzerland and Liechtenstein, **CY** Cyprus, **DE** Germany, **DK** Denmark, **ES** Spain, **FI** Finland, **FR** France, **GB** United Kingdom, **GR** Greece, **IE** Ireland, **IT** Italy, **LU** Luxembourg, **MC** Monaco, **NL** Netherlands, **PT** Portugal, **SE** Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- ☒ **OA** **OAPI Patent:** **BF** Burkina Faso, **BJ** Benin, **CF** Central African Republic, **CG** Congo, **CI** Côte d'Ivoire, **CM** Cameroon, **GA** Gabon, **GN** Guinea, **ML** Mali, **MR** Mauritania, **NE** Niger, **SN** Senegal, **TD** Chad, **TG** Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)*

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National patent *(if other kind of protection or treatment desired, specify on dotted line)*:

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- ☒ **GM** Gambia
- ☒ **GW** Guinea-Bissau .....
- ☒ **HU** Hungary .....
- ☒ **ID** Indonesia
- ☒ **IL** Israel .....
- ☒ **IS** Iceland
- ☒ **JP** Japan .....
- ☒ **KE** Kenya .....
- ☒ **KG** Kyrgyzstan .....
- ☒ **KP** Democratic People's Republic of Korea .....

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- ☒ **KR** Republic of Korea .....
- ☒ **KZ** Kazakstan .....
- ☒ **LC** Saint Lucia
- ☒ **LK** Sri Lanka
- ☒ **LR** Liberia
- ☒ **LS** Lesotho .....
- ☒ **LT** Lithuania
- ☒ **LU** Luxembourg .....
- ☒ **LV** Latvia
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- ☒ **MN** Mongolia
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Box No. VI PRIORITY CLAIM Further priority claims are indicated in the Supplemental Box ☐

The priority of the following earlier application(s) is hereby claimed:

Country *(in which, or for which, the application was filed)*	Filing Date *(day/month/year)*	Application No.	Office of filing *(only for regional or international application)*
item (1) FI	23 June 1997 (23.06.1997)	972704	
item (2)			
item (3)			

Mark the following check-box if the certified copy of the earlier application is to be issued by the Office which for the purposes of the present international application is the receiving Office (a fee may be required):

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Box No. VII INTERNATIONAL SEARCHING AUTHORITY

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Country (or regional Office): Date *(day/month/year):* Number:

Box No. VIII CHECK LIST

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1. ☐ separate signed power of attorney
2. ☐ copy of general power of attorney
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5. ☒ fee calculation sheet
6. ☐ separate indications concerning deposited microorganisms
7. ☐ nucleotide and/or amino acid sequence listing diskette)
8. ☒ other *(specify):* official action

Figure No. 2 of the drawings (if any) should accompany the abstract when it is published.

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request)

PATENTTITOIMISTO TEKNOPOLIS KOLSTER OY

Tapio Äkräs

For receiving Office use only

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2. Drawings: ☐ received ☐ not received:	
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5. International Searching Authority specified by the applicant: ISA/ SE	6. ☐ Transmittal of search copy delayed until search fee is paid

For International Bureau use only

Date of receipt of the record copy by the International Bureau: 17 JULY 1998 (17.07.98)

Vastaanottomenetelmä ja vastaanotin

Tekniikan ala

Keksinnön kohteena on vastaanottomenetelmä solukkoradiojärjestelmässä, joka käsittää kussakin solussa ainakin yhden tukiaseman, joka on yhteydessä alueellaan oleviin päätelaitteisiin, ja jossa järjestelmässä käytetään koodijakomonikäyttöä ja jossa menetelmässä vastaanotettu signaali muodostuu usealta lähettäjältä peräisin olevan signaalin summasignaalista, jotka signaalit koostuvat symboleista, ja jolle signaalille suoritetaan häiriönpoisto ja monen lähettäjän samanaikainen ilmaisu, ja jossa vastaanotetulle signaalille muodostetaan estimaatti.

Keksinnön kohteena on myös vastaanottomenetelmä solukkoradiojärjestelmässä, joka käsittää kussakin solussa ainakin yhden tukiaseman, joka on yhteydessä alueellaan oleviin päätelaitteisiin, jossa järjestelmässä käytetään koodijakomonikäyttöä, ja jossa menetelmässä vastaanotettu signaali muodostuu usealta lähettäjältä peräisin olevan signaalin summasignaalista, jolle signaalille suoritetaan häiriönpoisto ja monen lähettäjän samanaikainen ilmaisu.

Tekniikan taso

Esillä olevaa keksintöä voidaan soveltaa useissa eri tyyppisissä radiojärjestelmissä, joista eräs esimerkki on CDMA-järjestelmät. CDMA on hajaspektritekniikkaan perustuva monikäyttömenetelmä, jota on viime aikoina ryhdytty soveltamaan solukkoradiojärjestelmissä aiempien FDMA:n ja TDMA:n ohella. CDMA:lla on useita etuja verrattuna aiempiin menetelmiin, kuten esimerkiksi taajuussuunnittelun yksinkertaisuus sekä spektritehokkuus.

CDMA-menetelmässä käyttäjän kapeakaistainen datasignaali kerrotaan datasignaalia huomattavasti laajakaistaisemmalla hajotuskoodilla suhteellisen laajalle kaistalle. Tunnetuissa koejärjestelmissä käytettyjä kaistanleveyksiä ovat esimerkiksi 1,25 MHz, 10 MHz sekä 25 MHz. Kertomisen

yhteydessä datasignaali leviää koko käytettävälle kaistalle. Kaikki käyttäjät lähettävät samaa taajuuskaistaa käyttäen samanaikaisesti. Kullakin tukiaseman ja liikkuvan aseman välisellä yhteydellä käytetään omaa hajotuskoodia, ja käyttäjien signaalit pystytään erottamaan toisistaan vastaanottimissa kunkin käyttäjän hajotuskoodin perusteella. Hajotuskoodit pyritään valitsemaan siten, että ne ovat keskenään ortogonaalisia eli eivät korreloi toistensa kanssa.

Tavanomaisella tavalla toteutetuissa CDMA-vastaanottimissa olevat korrelaattorit tahdistuvat haluttuun signaaliin, joka tunnistetaan hajotuskoodin perusteella. Datasignaali palautetaan vastaanottimessa alkuperäiselle kaistalle kertomalle se uudestaan samalla hajotuskoodilla kuin lähetysvaiheessa. Ne signaalit, jotka on kerrottu jollain toisella hajotuskoodilla, eivät ideaalisessa tapauksessa korreloi ja palaudu kapealle kaistalle. Täten ne näkyvät kohinana halutun signaalin kannalta. Tavoitteena on siis ilmaista halutun käyttäjän signaali usean häiritsevän signaalin joukosta. Käytännössä hajotuskoodit eivät ole korreloimattomia ja toisten käyttäjien signaalit vaikeuttavat halutun signaalin ilmaisua vääristämällä vastaanotettua signaalia epälineaarisesti. Tätä käyttäjien toisilleen aiheuttamaa häiriötä kutsutaan monikäyttöhäiriöksi. Vastaavaa monikäyttöhäiriötä esiintyy myös muilla monikäyttömenetelmillä, kuten TDMA:lla ja FDMA:lla.

Monikäyttöhäiriön aiheuttaman signaalin laadun heikentymisen poistamiseksi on kehitetty lukuisia vastaanottomenetelmiä. Näitä on sekä perinteinen yhden käyttäjän vastaanotto että monen käyttäjän samanaikaisen ilmaisun mahdollistavat menetelmät. Perinteisessä yhden käyttäjän vastaanotossa vastaanotettua lähetettä korreloidaan lineaarisella sovitetulla suodattimella, joka ei ota huomioon muita lähetteen käsittämiä signaaleja kuin halutun käyttäjän signaalin. Tämä on yksinkertainen toteuttaa, mutta mo-

nikäyttöhäiriön poistossa erittäin tehoton.

On esitetty menetelmiä, joissa monikäyttöhäiriö poistetaan laajakaistaisesta signaalista ja ilmaisu puolestaan suoritetaan kapeakaistaisesta signaalista, josta hajotuskoodi on purettu. Eräs tällainen menetelmä on kuvattu julkaisussa Thielecke, Interference reduction Applied to Channel estimation in CDMA systems, Proceedings of Vehicular Technology Conference, 1994, Stockholm, joka otetaan viitteeksi. Tällaiset menetelmät ovat kuitenkin käytännössä vaikeita toteuttaa, koska signaalin prosessointi tapahtuu laajakaistaisena eli chippitasolla.

Optimaalinen monen käyttäjän ilmaisin (MUD, multiuser detector) koostuu joukosta lineaarisia sovitettuja suodattimia ja Viterbi-ilmaisimesta. Eräs tunnettu lineaarinen monen käyttäjän ilmaisin on LS-ilmaisin (least squares detector), jota kutsutaan dekorreloivaksi ilmaisimeksi. Tämä ilmaisin tarvitsee käytettyjen koodien keskinäisistä ristikorrelaatioista.

Tunnettujen menetelmien puutteena on edelleen se, että ne on kehitetty staattisille järjestelmille eli tilanteisiin, missä käyttäjien lukumäärä ei muutu. Käytännön radiojärjestelmissä on kuitenkin lukuisia ajan myötä muuttuvia tekijöitä, jotka tulisi ottaa huomioon vastaanotinta suunniteltaessa. Uusia käyttäjiä tulee soluun kanavanvaihdon tai uusien puhelujen myötä. Vierekkäisistä soluista tulevien häiriösignaalien määrä ja laatu myös vaihtelevat jatkuvasti.

Keksinnön tunnusmerkit

Esillä olevan keksinnön tarkoituksena onkin toteuttaa vastaanottomenetelmä ja vastaanotin, joilla aiempien ratkaisujen epäkohtia voidaan välttää. Keksinnön mukainen ratkaisu mahdollistaa nopean ja tarkan tahdistumisen, jonka ansioista sekä yhteydenmuodostus että häiriöpoiston laatu paranee.

Tämä saavutetaan johdannossa esitetyn tyyppisellä

menetelmällä, jolle on tunnusomaista, että estimaatti käsittää yhden tai useamman vastaanotetun käyttäjän signaalin estimaatin, ja että vastaanotetusta summasignaalista vähennetään symbolitasolla estimoitujen symboleiden vaikutus jolloin saadaan kapeakaistainen symbolitasoinen jäännössignaali.

Tämä saavutetaan myös johdannossa esitetyn tyyppisellä menetelmällä, jolle on tunnusomaista, että estimaatti käsittää yhden tai useamman vastaanotetun käyttäjän signaalin estimaatin,ja että vastaanotettu summasignaali korreloidaan tietyllä hajotuskoodilla, jolloin saadaan ensimmäinen symbolitasoinen signaali,ja että laskettua estimaattia korreloidaan samalla hajotuskoodilla, jolloin saadaan toinen symbolitasoinen signaali, ja että toinen symbolitasoinen signaali vähennetään ensimmäisestä symbolitasoisesta signaalista, jolloin saadaan kapeakaistainen symbolitasoinen jäännössignaali.

Keksinnön kohteena on lisäksi vastaanotin solukkoradiojärjestelmässä joka käsittää kussakin solussa ainakin yhden tukiaseman, joka on yhteydessä alueellaan oleviin päätelaitteisiin, jossa menetelmässä vastaanotettu signaali muodostuu usealta lähettäjältä peräisin olevan signaalin summasignaalista, joka vastaanotin käsittää välineet suorittaa signaalille häiriönpoisto ja monen lähettäjän samanaikainen ilmaisu ja välineet etsiä signaalien parametrejä. Keksinnön mukaiselle vastaanottimelle on tunnusomaista, että vastaanotin käsittää edelleen välineet poistaa vastaanotetusta symbolitasoisesta summasignaalista tunnettujen käyttäjien signaalien vaikutus, ja välineet estimoida kapeakaistaisesta jäännössignaalista tuntemattomien signaalien parametrit.

Keksinnön mukaisella menetelmällä saavutetaan useita etuja. Keksinnön mukainen menetelmä pystyy nopeasti havaitsemaan dynaamiset muutokset radiotien etenemisympäristössä, kuten uusien käyttäjien tai vieraiden häiritsijöi-

den signaalit. Useimmissa tapauksissa keksinnön mukainen ratkaisu vaatii myös vähemmän prosessointitehoa kuin aiemmat ratkaisut. Keksinnön mukainen ratkaisu ei vaadi suuria muutoksia olemassaoleviin laitteistoihin, vaan se voidaan ottaa käyttöön myös nykyisissä järjestelmissä vähäisin kustannuksin. Keksinnön edulliset toteutusmuodot selviävät epäitsenäisistä vaatimuksista.

Kuvioiden selitys

Seuraavassa keksintöä selitetään tarkemmin viitaten oheisten piirustusten mukaisiin esimerkkeihin, joissa

kuvio 1 esittää järjestelmää, jossa keksintöä voidaan soveltaa ja

kuvio 2 havainnollistaa keksinnön mukaisen vastaanottimen rakennetta lohkokaavion avulla.

Edullisten toimintamuotojen kuvaus

Esillä olevaa keksintöä voidaan soveltaa useissa eri tyyppisissä radiojärjestelmissä, joista eräs esimerkki on CDMA-järjestelmät. Jatkossa keksintöä selostetaan CDMA-järjestelmän yhteydessä, siihen kuitenkaan rajoittumatta.

Kuviossa 1 havainnollistetaan tyypillisen solukkoradiojärjestelmän rakennetta. Kuviossa on esitetty kaksi solua 100, 102, joissa kussakin on yksi tukiasema 104, 106. Solussa 100 on kolme aktiivista päätelaitetta 108 - 112, jotka kommunikoivat tukiaseman 100 kanssa. Vastaavasti solussa 102 on kaksi aktiivista päätelaitetta 116, 118, jotka kommunikoivat tukiaseman 106 kanssa.

Tukiasemissa vastaanotetaan päätelaitteiden signaalit ja suoritetaan monen käyttäjän samanaikainen ilmaisu vastaanotetuille signaaleille. Tarkastellaan tilannetta tukiaseman 104 kannalta. Tukiasema on siis yhteydessä alueellaan oleviin aktiivisiin päätelaitteisiin 108 - 112, joiden signaaleita 120 - 124 se vastaanottaa. Tukiaseman antennin vastaanottama summasignaali käsittää myös vierekkäisessä solussa olevan päätelaitteen signaalin 126, joka on siis vastaanottimen kannalta häiriösignaali. Tukiasema

104 suorittaa monen käyttäjän samanaikaisen ilmaisun jollain tunnetulla MUD-algoritmillä. Tässä se siis ilmaisee halutut signaalit 120 - 124 ja poistaa häiritsevän signaalin 126 vaikutuksen halutuista signaaleista. Kustakin halutusta signaalista voidaan poistaa luonnollisesti kaikkien toisten signaalien vaikutus, eikä ainoastaan vierekkäisestä solusta tulevaa signaalia. Tämä riippuu estimaatin luotettavuudesta ja käytännön rajoitteista.

Tarkastellaan seuraavaksi keksinnön mukaisen vastaanottimen, tässä esimerkissä tukiaseman rakennetta kuviossa 2 esitetyn lohkokaavion avulla. Vastaanotin käsittää antennin 200, jolla usealta lähettäjältä peräisin olevien signaalien summasignaali vastaanotetaan. Antenni voi olla yksittäinen antenni tai kahdesta tai useammasta antennista muodostuva antenniryhmä. Antennilta signaali viedään radiotaajuusosille 202, joissa signaali tyypillisesti vahvistetaan ja muunnetaan väli- tai kantataajuudelle. Radiotaajuusosilta signaali viedään näytteenottovälineille 204 eli analogia-digitaalimuuntimelle, jossa signaali muunnetaan digitaaliseen muotoon ottamalla siitä näytteitä halutulla näytteenottotaajuudella.

Näytteenottovälineiltä 202 signaali viedään korrelaattoripankkiin 206, joka käsittää joukon korrelaattoreita tai sovitettuja suodattimia, jotka kukin tahdistuvat yhteen summasignaalin signaalikomponenteista, jonka ne tunnistavat signaaliparametrien perusteella. Korrelaattorit purkavat signaalien hajotuskoodauksen eli muuntavat sen kapeakaistaiseksi. Kapeakaistaiset signaalit 212 viedään ilmaisuyksikölle 208, jossa suoritetaan monen käyttäjän samanaikainen ilmaisu. Ilmaisuyksiköltä saatavat haluttujen signaalien symboleiden pehmeät päätökset 214 viedään jälkikäsittely-yksikköön 216 ja edelleen vastaanottimen muihin osiin. Jälkikäsittely-yksikössä 216 signaalille suoritetaan esimerkiksi lomituksen purkua ja kanavadekoodausta. Keksinnön kannalta signaalin käsittelyllä ilmaisu-

yksikön jälkeen ei ole oleellista merkitystä.

Korrelaattoripankin tarvitsemat signaaliparametrit käsittävät signaalin lähetyksessä käytetyn hajotuskoodin, datanopeuden, suhteellisen viiveen ja mahdollisesti myös amplitudin. Kun mikä tahansa parametreistä muuttuu, täytyy korrelaattoria päivittää. Hajotuskoodi saattaa vaihtua, kun käyttäjä lähtee tai tulee soluun, mikä saattaa tapahtua kanavanvaihdon tai laitteen päällekytkemisen kautta.

Koska tieto näistä parametreistä on tärkeää, täytyy vastaanottimen luonnollisesti tarkkailla ja estimoida näitä vaihtuvia suureita. Tämä tapahtuu ns. etsijäyksikössä 210. Näytteenottovälineiltä 202 vastaanotettu summasignaali viedään korrelaattoripankin ohella etsijäyksikköön 210, joka etsii uusia signaalikomponentteja ja niiden parametrejä.

Etsijäyksikön 210 estimoimat ja laskemat signaaliparametrit käsittävät aktiivisten käyttäjien lukumäärän, fyysiset kanavat, kanavan impulssivasteen, kehysparametrit ja näiden funktiot. Etsijäyksikössä lasketaan myös koodien välistä korrelaatiomatriisia. Korrelaatiomatriisin täytyy päivittää kanavan dynaamisten muutosten myötä, kun viiveet ja bittinopeudet muuttuvat. Ilmaisuyksikkö käyttää näitä tietoja laskeakseen signaalien välisiä korrelaatioita monen käyttäjän samanaikaisessa ilmaisussa ja häiriönpoistossa.

Keksinnön mukaisessa ratkaisussa etsijälohkon toimintaa helpotetaan ratkaisevasti siten, että paitsi vastaanotettua summasignaalia etsijäyksikköön viedään sisäänmenona signaali, jossa vastaanotetusta summasignaalista on poistettu tunnettujen käyttäjien signaalien vaikutus. Tästä jäännössignaalista tuntemattomien signaalien parametrit voidaan estimoida huomattavasti helpommin kuin alkuperäisestä summasignaalista. Vastaanottimen nopea toiminta on tässä tärkeää etenkin pakettimuotoisen informaation yhteydessä.

Kun uusi signaali on löydetty ja sen parametrit tunnistettu, on kaksi vaihtoehtoa. Mikäli signaali on häiriösignaali, esimerkiksi naapurisoluun kuuluvan päätelaitteen signaali, niin estimoitujen parametrien avulla löydetyn signaalin vaikutus poistetaan vastaanotetusta signaalista. Mikäli signaali puolestaan on haluttu signaali, esimerkiksi tukiaseman solun alueelle siirtymässä oleva päätelaite, joka haluaa muodostaa makrodiversiteettiyhteyden tukiasemaan, niin estimoitujen parametrien avulla löydetty signaali ilmaistaan monen lähettäjän samanaikainen ilmaisua käyttäen.

Tuntemattomien signaalien estimoinnissa voi esiintyä erilaisia tapauksia. Vastaanottimella voi olla ennakkoon jotain tietoa etsittävistä signaaleista. Signaalit voivat tulla esimerkiksi naapurisolusta, jolloin naapurisolun tukiaseman voi välittää ennakkoon mahdollisten häiriösignaalien parametrejä. Tällöin esimerkiksi hajotuskoodi saattaa olla tunnettu, mutta viivettä ei tiedetä. Toisaalta synkronisessa järjestelmässä saattaa viive olla tunnettu, mutta hajotuskoodi tuntematon. Häiriösignaali saattaa myös olla sellainen, josta ei ole etukäteen mitään parametria tiedossa. Toisaalta esimerkiksi pakettiliikenteessä tai random access -lähetteen yhteydessä koodi tunnetaan, mutta viive on tuntematon.

Tunnettaessa osa etsittävien signaalien parametreistä näitä tietoja käytetään hyväksi muiden parametrien etsinnässä. Tällöin etsintä luonnollisesti nopeutuu.

Esimerkiksi, jos tiedetään joukko potentiaalisia häiritsijöitä, niin etukäteen voidaan laskea haluttujen käyttäjien ja näiden potentiaalisten häiriösignaalien väliset ristikorrelaatiot. Seuraavaksi poistetaan vastaanotetusta summasignaalista tunnettujen signaalien vaikutus, käyttäen siis hyväksi estimoituja symboleita, tunnettuja viiveitä ja koodeja. Tämän jälkeen jäännössignaalista etsitään tuntemattomia signaaleita käyttäen ennakkoon olevaa

informaatiota hyväksi hakuikkunan pienentämiseksi.

Tarkastellaan seuraavaksi hieman keksinnön mukaisen ratkaisun matemaattista pohjaa. Kuvataan vastaanotettua signaalia r kaavalla

$$r = S_1 A_1 b_1 + n$$

missä S-matriisi sisältää hetkellä t kaikkien aktiivisten käyttäjien koodit, A sisältää hetkellä t kaikkien aktiivisten käyttäjien kanavakertoimet, b sisältää hetkellä t kaikkien aktiivisten käyttäjien bitit ja n on kohina. Kun uusi käyttäjä tulee systeemiin, tämä ilmenee yllä mainitussa kaavassa siten, että matriisiin S tulee uusi sarake, joka on tunnistettava.

Eräs tunnettu menetelmä ongelman ratkaisemiseksi on korreloida vastaanotettua signaalia tunnetulla koodilla s_2, joka ei siis kuulu matriisiin S:

$$s_2^H \underline{r}.$$

Korreloinnin perusteella tehdään päätös, oliko uusi signaali lähetetty tiettyä koodia käyttäen ja millä viiveellä signaali on vastaanotettu. Koodeja ja viiveitä käydaan läpi yksi kerrallaan, kunnes korrelointituloksen avulla saadaan lähettäjä selville.

Toinen menetelmä, joka on esitetty aiemmin mainitussa viitteessä Thielecke, on se, että häiriönpoistosta tehdään päätös laajakaistaisen residuaalisignaalin perusteella:

$$s_2^H [\underline{r} - \hat{S}_1 \hat{A}_1 \hat{b}_1],$$

jossa vastaanotetusta signaalista vähennetään laajakaistainen estimaatti.

Keksinnön mukainen edullinen ratkaisu perustuu kapeakaistasignaalin käsittelyyn, eli signaaliin, joka saadaan rake-haarojen ulostuloista. Menetelmän mukaisesti generoidaan ensin tunnetun signaalin estimaatti

$$\underline{\hat{r}}_1 = \hat{S}_1 \hat{A}_1 \hat{b}_1.$$

Seuraavaksi korreloidaan residuaalisignaalia etsittävällä koodilla

$$\hat{z}_{12} = \hat{s}_2^H [\ \hat{S}_1 \hat{A}_1 \hat{b}_1\ ] = \hat{S}_2^H \hat{r}_1,$$

jolloin saadaan interferenssiestimaatti kapeakaistaiselle signaalille. Seuraavaksi vähennetään $\hat{z}_{12}$ rake-haarojen ulostulosta estimoitu kapeakaistainen signaali:

$$z_{r\omega} = z_2 - \hat{z}_{12}$$

ja tehdään päätös kapeakaistaisesta residuaalisignaalista. Käyttäjälle k päätös tehdään signaalista

$$z_{res} + \hat{a}_k \hat{b}_k,$$

missä on $\hat{a}_k$ on yhden käyttäjän kanavaestimaatti.

Päätös voi perustua esimerkiksi residuaalisignaalin tehoon tai kanava- tai amplitudiestimaattiin. Residuaalisignaali voidaan yhdistää symbolitasolla joko koherentisti tai epäkoherentisti. Koherentti yhdistely voidaan toteuttaa lähettämällä tunnettua opetussekvenssiä tai päätöstakaisinkytkennän avulla. Jos s_2 ei ole uudessa signaalissa, niin residuaalisignaalin signaalikohinasuhde on erittäin huono, päinvastaisessa tapauksessa operaatio vähentää interferenssiä ja parantaa signaalikohinasuhdetta huomattavasti. Keksinnön mukaisen menetelmän suuri etu on siinä, ettei ristikorrelaatioita tarvitse laskea missään vaiheessa, joten menetelmä on huomattavasti kevyempi operaatio toteuttaa, vaikka koodi muuttuisikin symboli symbolilta. Toisaalta, jos koodi pysyy vakiona, eli ei muutu symboli symbolilta, niin edellä mainittu laskenta voidaan kuitenkin toteuttaa myös siten, että lasketaan ristikorrelaatiomatriisi $S_2^H * S_1$ ja sen jälkeen vasta $\hat{A}_1 \hat{b}_1$. Koska koodi ei muutu, niin laskennan määrä ei kasva huomattavasti.

Kapeakaistaisen residuaalisignaalin laskeminen on edelleen melko vaativa toimenpide, joten menetelmät, joilla laskemisen taajuutta voidaan vähentää, ovat eduksi. Yksi tällainen tapa on soveltaa perinteistä korrelaattoria

$$s_2^H r,$$

jonka avulla etsitään joukko testiviiveitä, joiden joukossa oikea viive/koodi on suurella todennäköisyydellä. Kaikille näin saaduille testiviiveille voidaan laskea residu-

aalisignaaliin z_{rw} perustuva tarkempi viive-koodiestimaatti. Näin saadaan kompleksisuus putoamaan kertoimella $|L_1|/|L_2|$, missä $|L_1|$ on etsittyjen testiviiveiden lukumäärä ja $|L_2|$ kaikkien mahdollisten viiveiden määrä. Laskenta voidaan luonnollisesti tehdä joko usealle testiviiveelle rinnakkain tai sekventiaalisesti yksi viive kerrallaan.

Keksinnön toisessa edullisessa toteutusvaihtoehdossa vastaanotetusta signaalista poistetaan ainakin yhden häiriösignaalin estimaatti ja saadusta jäännössignaalista estimoidaan tuntemattomien signaalien parametrit. Tämä vaihtoehto on edullinen esimerkiksi random access -signaalin ollessa kyseessä. Tällöinhän häiriösignaalin vaikutus on kertaluonteinen. Signaalin vaikutus voidaan poistaa vastaanotetusta lähetteestä, ja näin saadusta vähemmän häiriöllisestä residuaalisignaalista estimoidaan tuntemattomien signaalien parametrit. Häiriösignaalin estimaatti käsittää kompleksisen amplitudin, kanavakertoimen, viiveen jne.

Tarkastellaan seuraavaksi keksinnön mukaisen vastaanottimen, tässä esimerkissä tukiaseman rakennetta kuviossa 2 esitetyn lohkokaavion avulla. Vastaanotin käsittää siis korrelaattoripankin 206, joka käsittää joukon korrelaattoreita tai sovitettuja suodattimia, joiden ulostulossa on tunnetuilla hajotuskoodeilla kerrotut kapeakaistaiseksi muunnetut signaalit 212. Ilmaisuvälineet 208 suorittavat signaaleille 212 häiriönpoiston ja monen lähettäjän samanaikainen ilmaisun.

Vastaanotin käsittää edelleen välineet 210 etsiä signaalien parametrejä. Etsijävälineille tulee yhtenä sisäänmenona vastaanotettu summasignaali. Ilmaisuvälineiltä 208 tulee etsijävälineille tieto 218 tunnettujen signaalien parametreistä. Signaali 218 käsittää esimerkiksi tiedon ilmaistujen signaalien lukumäärästä, alustavat viive-estimaatit kullekin signaalille ja aktiivisen koodijoukon. Etsijävälineet poistavat vastaanotetusta summasignaalista

tunnettujen käyttäjien signaalien vaikutuksen ja estimoivat jäännössignaalista tuntemattomien signaalien parametrit, kuten aiemmin on kuvattu. Etsijävälineiden laskemat parametrit 220 viedään hyödynnettäviksi korrelaattoripankille 206 sekä ilmaisuyksikölle 208. Etsijävälineet 210 ja ilmaisuvälineet 208 voidaan toteuttaa käytännössä edullisesti ohjelmallisesti signaali- tai yleisprosessorin avulla tai vaihtoehtoisesti erilliskomponenttien tai ASIC-piirien avulla.

Vaikka keksintöä on edellä selostettu viitaten oheisten piirustusten mukaiseen esimerkkiin, on selvää, ettei keksintö ole rajoittunut siihen, vaan sitä voidaan muunnella monin tavoin oheisten patenttivaatimusten esittämän keksinnöllisen ajatuksen puitteissa.

Patenttivaatimukset:

1. Vastaanottomenetelmä solukkoradiojärjestelmässä, joka käsittää kussakin solussa ainakin yhden tukiaseman, joka on yhteydessä alueellaan oleviin päätelaitteisiin, ja jossa järjestelmässä käytetään koodijakomonikäyttöä ja jossa menetelmässä vastaanotettu signaali muodostuu usealta lähettäjältä peräisin olevan signaalin summasignaalista, jotka signaalit koostuvat symboleista, ja jolle signaalille suoritetaan häiriönpoisto ja monen lähettäjän samanaikainen ilmaisu, ja jossa vastaanotetulle signaalille muodostetaan estimaatti, t u n n e t t u siitä, että

estimaatti käsittää yhden tai useamman vastaanotetun käyttäjän signaalin estimaatin,

ja että vastaanotetusta summasignaalista vähennetään symbolitasolla estimoitujen symboleiden vaikutus jolloin saadaan kapeakaistainen symbolitasoinen jäännössignaali.

2. Vastaanottomenetelmä solukkoradiojärjestelmässä, joka käsittää kussakin solussa ainakin yhden tukiaseman, joka on yhteydessä alueellaan oleviin päätelaitteisiin, jossa järjestelmässä käytetään koodijakomonikäyttöä, ja jossa menetelmässä vastaanotettu signaali muodostuu usealta lähettäjältä peräisin olevan signaalin summasignaalista, jolle signaalille suoritetaan häiriönpoisto ja monen lähettäjän samanaikainen ilmaisu, t u n n e t t u siitä, että

estimaatti käsittää yhden tai useamman vastaanotetun käyttäjän signaalin estimaatin,

ja että vastaanotettu summasignaali korreloidaan tietyllä hajotuskoodilla, jolloin saadaan ensimmäinen symbolitasoinen signaali,

ja että laskettua estimaattia korreloidaan samalla hajotuskoodilla, jolloin saadaan toinen symbolitasoinen signaali, ja että

toinen symbolitasoinen signaali vähennetään ensim-

mäisestä symbolitasoisesta signaalista, jolloin saadaan kapeakaistainen symbolitasoinen jäännössignaali.

3. Patenttivaatimuksen 1 tai 2 mukainen menetelmä, t u n n e t t u siitä, että kapeakaistaisesta jäännössignaalista estimoidaan tuntemattomien signaalien parametrit.

4. Patenttivaatimuksen 1 mukainen menetelmä, t u n n e t t u siitä, että parametrien avulla tehdään päätös löydettiinkö uusia käyttäjäsignaaleita.

5. Patenttivaatimuksen 3 mukainen menetelmä, t u n n e t t u siitä, että estimoitujen parametrien avulla löydetyt signaalit ilmaistaan monen lähettäjän samanaikainen ilmaisua käyttäen.

6. Patenttivaatimuksen 1 tai 2 mukainen menetelmä, t u n n e t t u siitä, että vastaanotettu summasignaali viedään ensin joukolle sovitettuja suodattimia (206), joissa estimoidaan tunnettujen signaalien parametrit, jotka signaalit viedään ilmaisimelle (208), jossa suoritetaan monen lähettäjän samanaikainen ilmaisu.

7. Patenttivaatimuksen 6 mukainen menetelmä, t u n n e t t u siitä, että signaalien parametrit käsittävät signaalien vaiheen, amplitudin ja käytetyn hajotuskoodin.

8. Patenttivaatimuksen 6 mukainen menetelmä, t u n n e t t u siitä, että signaalien parametrit estimoidaan rinnakkaisesti.

9. Patenttivaatimuksen 6 mukainen menetelmä, t u n n e t t u siitä, että signaalien parametrit estimoidaan rinnakkaisesti.

10. Patenttivaatimuksen 6 mukainen menetelmä, t u n n e t t u siitä, että signaalien parametrit estimoidaan sarjamuotoisesti.

11. Patenttivaatimuksen 6 mukainen menetelmä, t u n n e t t u siitä, että tunnettaessa osa tuntemattomien signaalien parametreistä näitä tietoja käytetään hyväksi muiden parametrien etsinnässä.

12. Patenttivaatimuksen 1 tai 2 mukainen menetelmä,

t u n n e t t u siitä, että jäännössignaali käsittää käyttäjien symboleja ja että symbolit yhdistellään epäkoherentisti.

13. Patenttivaatimuksen 1 tai 2 mukainen menetelmä, t u n n e t t u siitä, että jäännössignaali käsittää käyttäjien symboleja ja että symbolit yhdistellään koherentisti.

14. Patenttivaatimuksen 1 tai 2 mukainen menetelmä, t u n n e t t u siitä, että parametrien estimointi suoritetaan useassa vaiheessa siten, että suoritetaan ensin alustavien estimaattien haku, jonka jälkeen löydettyjen alustavien estimaattien joukosta estimoidaan tarkempi lopullinen estimaatti.

15. Vastaanotin solukkoradiojärjestelmässä joka käsittää kussakin solussa ainakin yhden tukiaseman, joka on yhteydessä alueellaan oleviin päätelaitteisiin, jossa menetelmässä vastaanotettu signaali muodostuu usealta lähettäjältä peräisin olevan signaalin summasignaalista, joka vastaanotin käsittää välineet (208) suorittaa signaalille häiriönpoisto ja monen lähettäjän samanaikainen ilmaisu ja välineet (210) etsiä signaalien parametrejä, t u n n e t t u siitä, että vastaanotin käsittää edelleen välineet (210) poistaa vastaanotetusta symbolitasoisesta summasignaalista tunnettujen käyttäjien signaalien vaikutus, ja välineet (210) estimoida kapeakaistaisesta jäännössignaalista tuntemattomien signaalien parametrit.

16. Patenttivaatimuksen 15 mukainen vastaanotin, t u n n e t t u siitä, että vastaanotin käsittää edelleen välineet (208) poistaa estimoitujen parametrien avulla löydettyjen signaalien vaikutus vastaanotetusta signaalista.

17. Patenttivaatimuksen 15 mukainen vastaanotin, t u n n e t t u siitä, että vastaanotin käsittää edelleen välineet (208) ilmaista estimoitujen parametrien avulla löydetyt signaalit monen lähettäjän samanaikaista ilmaisua käyttäen.

(57) Tiivistelmä
Keksinnön kohteena on vastaanottomenetelmä ja vastaanotin järjestelmässä joka käsittää kussakin solussa tukiaseman, joka on yhteydessä alueellaan oleviin päätelaitteisiin. Vastaanotettu signaali muodostuu usealta lähettäjältä peräisin olevan signaalin summasignaalista. Vastaanotin käsittää välineet (208) suorittaa signaalille häiriönpoisto ja monen lähettäjän samanaikainen ilmaisu ja välineet (210) etsiä signaalien parametrejä. Tarvittavan laskentakapasiteetin vähentämiseksi vastaanotin käsittää edelleen välineet (210) poistaa vastaanotetusta summasignaalista tunnettujen käyttäjien signaalien vaikutus, ja välineet (210) estimoida kapeakaistaisesta jäännössignaalista tuntemattomien signaalien parametrit.

(Kuvio 2)

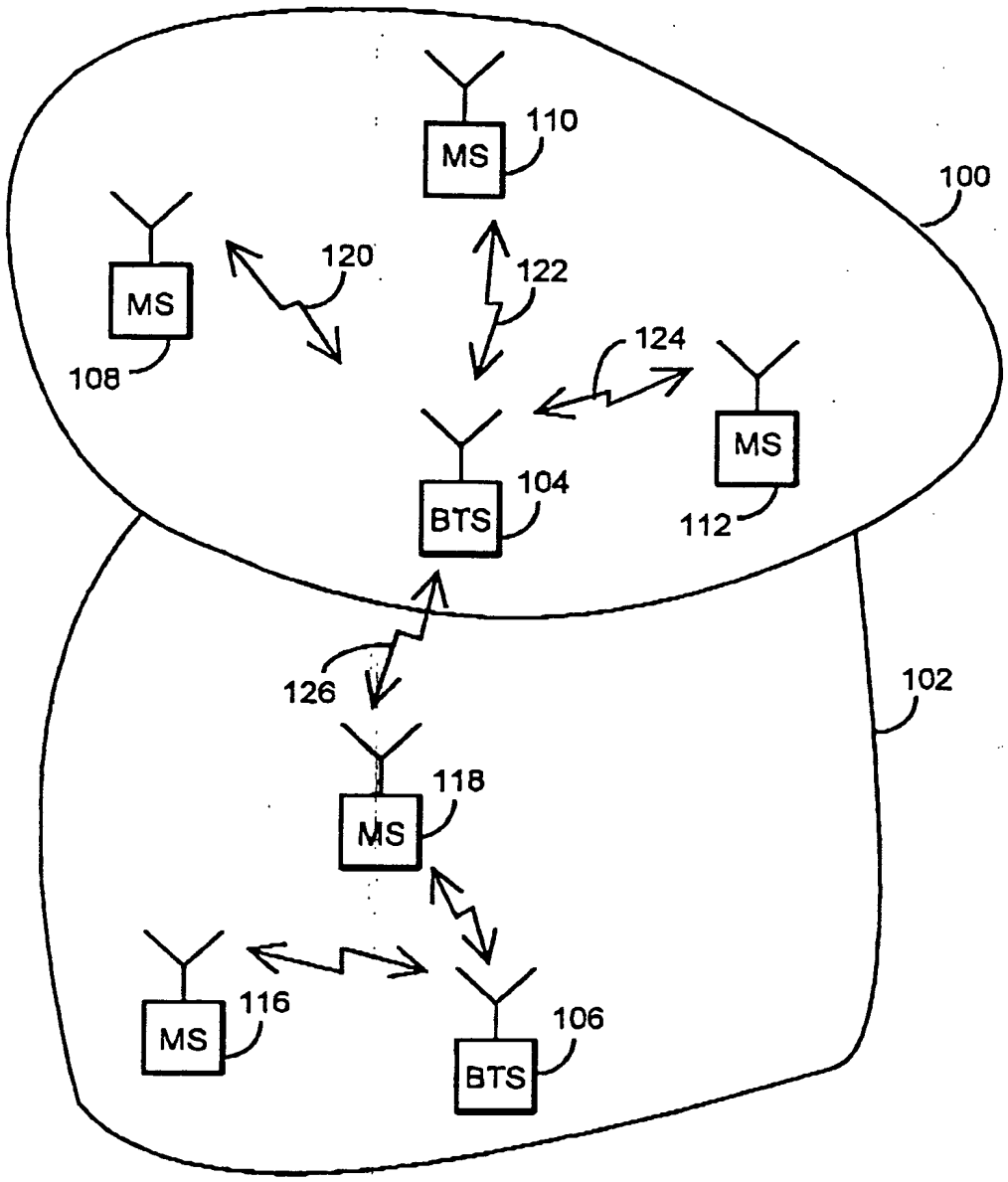
MS
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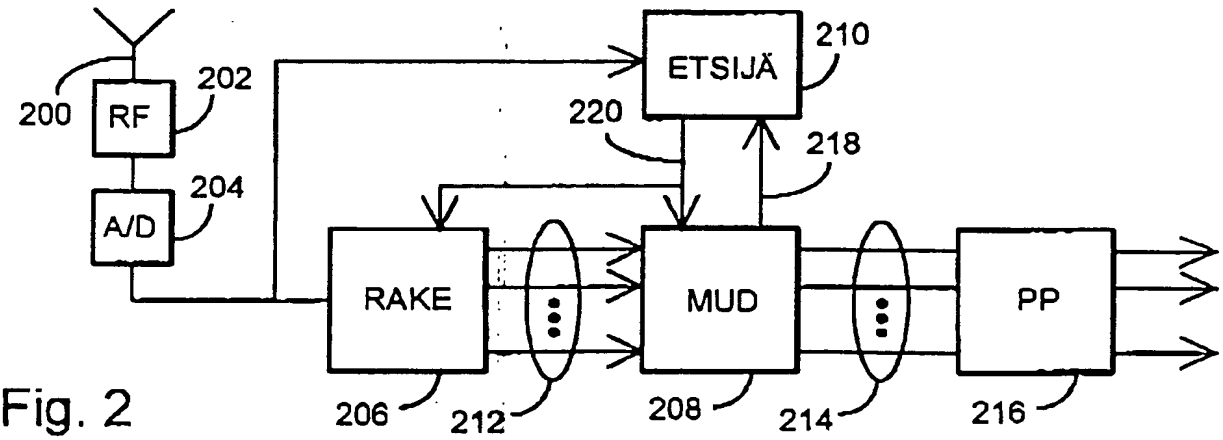
Fig. 1


200
RF
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ETSIJÄ
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RAKE
MUD
PP
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208
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Fig. 2